Paths to Clean Vehicle Technology and Alternative Fuels Implementation in San Bernardino County

Task 4.1: Barriers and Challenges to Implementation of Clean Vehicle and Fuel Technologies

May 2019

Submitted to:
SBCTA and SCAG

Submitted by:
ICF

Table of Contents

1. Introduction

Clean vehicle technologies and alternative fuels provide numerous opportunities to reduce greenhouse gas (GHG) and criteria air pollutant emissions from the on-road transportation sector. However, scaling the transition to cleaner vehicles and fuels requires a paradigm shift in the manner that public and private organizations approach transportation. This technical memo identifies the economic, technological, policy, and other barriers associated with this transition, with a specific focus on San Bernardino County.

The first section of the technical memo focuses on challenges to the deployment of alternative fuel light-duty vehicles (LDV), including electric vehicles (EVs), fuel cell vehicles (FCVs), and ethanol-fueled internal combustion engine (ICE) vehicles. The second section addresses the challenges to the growth of alternative fuel medium-duty vehicles (MDV) and heavy-duty vehicles (HDV), including EVs, FCVs, natural gas vehicles (NGVs), and vehicles running on liquid biofuels. The final section discusses regulatory authority, which applies to all vehicle types.

This document provides a foundation for the remainder of Task 4, which will identify and prioritize strategies for overcoming barriers and for implementing one or more of the clean vehicle and fuel scenarios analyzed in Task 3. Of particular interest will be strategies that can be implemented by local and regional government agencies, utilities, institutions, businesses, and other entities in and around San Bernardino County.

2. Light-Duty Vehicles

Electric Vehicles

Battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) represent a viable alternative fuel vehicle technology in the LDV segment. Supported by a number of federal, state, local, and utility incentive programs, cumulative statewide EV sales have surpassed 650,000 units.[1] However, EVs face several critical barriers that may slow their adoption in the near-term, including: high upfront vehicle costs, lack of model diversity and availability, lack of education and awareness of EVs, and lack of charging infrastructure.

The barriers to EV adoption are evident in the current market penetration in San Bernardino County. EVs comprise approximately 0.7% of registered vehicles in the County as of January 1, 2019.[2] In comparison, the statewide average EV penetration surpassed 1.6% in the same timeframe.[3] County and State EV

[1] https://www.veloz.org/
[2] https://www.dmv.ca.gov/portal/wcm/connect/e52e6d02-6fa6-483a-bbcd-d888f1b4035b/MotorVehicleFuelTypes_County_190913.pdf?MOD=AJPERES&CVID=
[3] https://www.dmv.ca.gov/portal/wcm/connect/fafd3447-8e14-4ff6-bb98-e85f3aa9a207/ca_dmv_stats.pdf?MOD=AJPERES&CVID=; https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/

registrations per capita figure were 0.005 and 0.013, respectively – suggesting that EV penetrations are lower in San Bernardino County than other parts of the state.[4]

High Upfront Vehicle Costs

The upfront price differential between EVs and comparable ICE vehicles is primarily driven by the cost of the vehicle battery. These costs are typically expressed in terms of dollars per kilowatt-hour ($/kWh) of energy storage. Bloomberg New Energy Finance's industry survey of battery costs yielded a volume-weighted average pack cost of $176/kWh in 2018 – meaning a 60 kWh EV battery costs approximately $10,500.[5] While battery pack costs are expected to decline as a result of learning by doing and economies of scale, EVs are not expected to reach upfront cost parity with comparable ICE vehicles until mid- to late-2020s.[6] This upfront price differential will continue to challenge EV sales among price-sensitive drivers that heavily discount long-term costs in vehicle purchase decisions. The table below provides examples of ICE vehicle prices and comparable EV model prices.[7]

Table 1 Price Comparison Between ICE Vehicle and EV Models

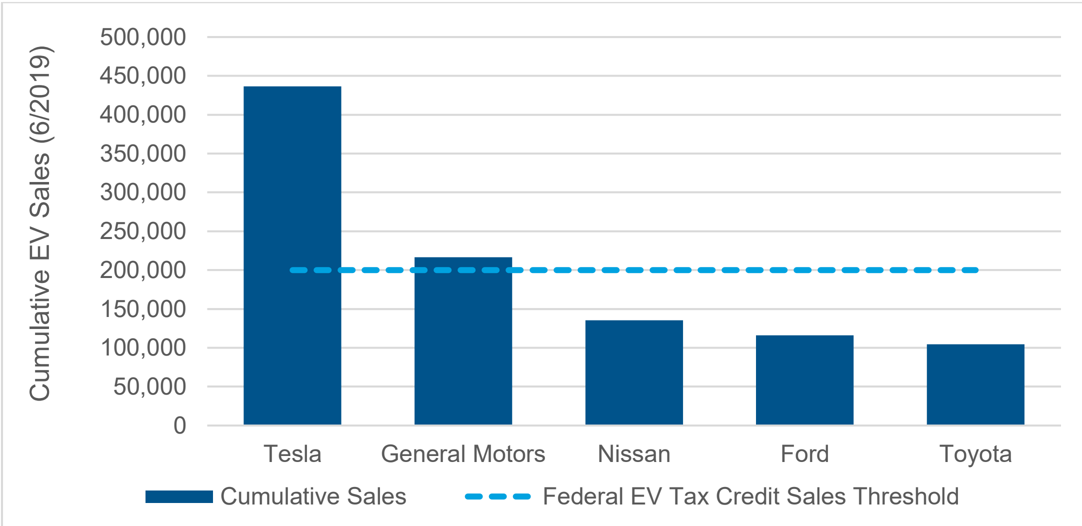
2019 ICE Vehicle Model Base MSRP	2019 EV Model Base MSRP (without incentives)	EV Price Difference
Chrysler Pacifica: $27,235	**Chrysler Pacifica Hybrid** (PHEV): $40,245	+48%
Honda Accord: $23,720	**Honda Clarity Electric:** $36,320	+53%
	Honda Clarity Plug-In Hybrid: $33,400	+41%
Hyundai Kona: $19,990	**Hyundai Kona EV:** $36,950	+85%
Kia Niro: $23,490	**Kia Niro EV:** $38,500	+64%
	Kia Niro Plug-In Hybrid: $28,500	+21%
Toyota Prius: $23,770	**Toyota Prius Prime** (PHEV): $27,350	+15%
Volkswagen Golf: $21,845	**Volkswagen eGolf:** $31,895	+46%

Uncertainty surrounding the availability of the federal EV tax credit also contributes to EVs' upfront cost challenges. Under Section 30D of the U.S. tax code, newly purchased EVs are eligible for a $2,500 to $7,500 tax credit.[8] However, the full tax credit only applies to the first 200,000 EVs sold per automaker.

[4] *Id.*
[5] Bloomberg New Energy Finance, "A Behind the Scenes Take on Lithium-ion Battery Prices", March 5, 2019, available at: https://about.bnef. com/blog/behind-scenes-take-lithium-ionbattery-prices/
[6] Lutsey and Nicholas, Update on electric vehicle costs in the United States through 2030, April 2, 2019, available at: https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf
[7] These prices do not take into account the incentives that are available for certain EV models, which typically reduce but do not eliminate the upfront purchase price gap between EVs and ICE vehicles. Also note that some EVs have better options/trim packages than the comparable ICE model, which contributes to a higher purchase price.
[8] The individual vehicle tax credit amount is determined by the capacity (kWh) of the EV battery. https://www.irs.gov/businesses/plug-in-electric-vehicle-credit-irc-30-and-irc-30d

Once the 200,000 unit limit is reached, the tax credit value decreases on a quarterly basis until it is phased out completely approximately one year after the automaker surpasses the threshold. The graph below illustrates the relationship between the top five leading EV automakers cumulative EV sales and the federal EV tax credit sales threshold.

Figure 1 Leading Automaker Domestic EV Sales and the Federal EV Tax Credit Sales Threshold



Tesla was the first automaker to surpass the sales threshold in July 2018 and General Motors followed suit in December 2018. The early phase out and elimination of these tax credits could potentially have negative near-term sales implications for the Tesla Model 3 and Chevy Bolt – two of the most popular EVs sold in California and the United States. By setting a fixed sales threshold for every automaker, the federal tax credit effectively penalizes early market movers that made significant investments in developing EV technologies and makes their products less competitive relative to automakers that have not delivered comparable EV models and sales. This feature of the federal EV tax credit may ultimately slow EV adoption in the near term as more automakers reach the tax credit sales limit and upfront EV costs remain higher than similar ICE vehicles in the early 2020s. Efforts have been made to extend the credit: in April 2019, Sen. Debbie Stabenow (D-MI) introduced the Driving America Forward Act.[9] However, the bill has not been brought to a vote as of the time this report was written. Aside from automaker eligibility issues, the federal EV tax credit may not provide value to drivers that do not have enough tax liability to take advantage of the full credit value. As a result, the federal tax credit may not be considered an equitable solution for providing EV incentives to low-income drivers.

In addition to declining federal tax incentives, California's Clean Vehicle Rebate Project (CVRP) per-vehicle incentives declined in December 2019. The CVRP rebates, which have supported the purchase of over 350,000 EVs in the state, dropped from $2,500 to $2,000 per vehicle for BEVs and $1,500 to $1,000 per vehicle for PHEVs for rebate applicants that do not qualify for elevated low- and moderate-income incentives.[10] The CVRP will also introduce new eligibility criteria that precludes some EV models from

[9] https://www.congress.gov/bill/116th-congress/senate-bill/1094
[10] Rebate levels for income qualified customers remain unchanged in the CVRP modification. https://cleanvehiclerebate.org/eng/faqs/what-should-i-know-about-december-3rd-program-changes

participating in the rebate program based on Manufacturer Suggested Retail Price caps and minimum all-electric ranges. California's EV incentives remain some of the most robust in the country, but reducing per-vehicle rebate levels and placing additional restrictions on model eligibility may put additional pressure on EV sales in the near-term while upfront EV costs remain relatively high: according to the San Bernardino County Zero Emission Vehicle Readiness and Implementation Plan, an estimated 69% of BEVs and 47% of PHEVs purchased between April 2016 and June 2018 were purchased with CVRP incentives.[11]

Coupled with declining EV incentives, California also plans to impose a new $100 annual registration fee for EVs beginning with model year 2020 vehicles. The Road and Repair Accountability Act of 2017 (SB 1) raises petroleum fuel consumption taxes to fund road infrastructure improvements and also requires that new EVs pay an additional fee in lieu of contributing via gasoline and diesel tax increases. In a report required by the California Assembly, the University of California – Davis finds that this fee suffers from several deficiencies.[12] Aside from running directly counter to the state's incentives to advance EV adoption, the annual registration fee is significantly higher than what comparable ICE vehicles pay on an energy-equivalent basis for gasoline, it penalizes PHEV drivers that pay the fee and gas taxes, it is disconnected from road usage impacts, and ultimately does not address long-term infrastructure funding needs. Although the fee is minor relative to the cost of a new vehicle, it further discourages drives from switching to EVs if they perceive EVs to be less economical than ICE vehicles. To advance EVs while generating sufficient revenue to support transportation infrastructure, California may need to adopt different policy mechanisms that properly account for both objectives.

EV fueling and maintenance costs are typically lower than comparable ICE vehicles, but these savings may not be large or immediate enough to overcome the EV purchase price premium for some consumers. The Department of Energy's eGallon calculator estimates the cost to "fuel up" an EV on a gallon-equivalent basis currently stands at $1.81 compared to $3.92 for a gallon of gasoline.[13] An EV charging under Southern California Edison's residential time-of-use rate (TOU-EV-1) during low-cost, off-peak periods of the day can refuel at costs that approach $1 per gallon-equivalent.[14] However, these fuel and associated maintenance cost savings must be realized over several years before a driver can recoup the upfront purchase price premium relative to a comparable ICE vehicle. For a vehicle owner who drives 12,000 miles per year, the payback period needed to recover the purchase price premium of an EV without incentives may be 8-10 years.[15]

Current petroleum fuel price trends magnify this challenge: while oil prices have recovered from decade lows in 2016, they remain lower than levels seen in the early post-Recession years – keeping gasoline

---

[11] https://www.gosbcta.com/wp-content/uploads/2019/11/SBCOG-ZEV-Plan_Final-Online-Version-11619.pdf

[12] Alan Jenn, PhD., *Assessing Alternatives to California's Electric Vehicle Registration Fee*, December 2018, available at: https://escholarship.org/uc/item/62f72449

[13] https://www.energy.gov/maps/egallon Accessed November 18, 2019.

[14] Assumes the TOU-EV-1 off-peak rate of $0.13 per kWh, EV efficiency of .27 kWh per mile, and comparable gasoline vehicle efficiency of 28.6 miles per gallon.

[15] Assumes an EV price premium of $10,000 over the reference vehicle, electricity prices between $0.13-0.17/kWh, gasoline prices between $3.50-3.70/gallon, BEV efficiency of 0.27 kWh/mile, and ICE vehicle efficiency of 25-29 miles per gallon. For simplicity, does not assume differences in maintenance costs.

prices under $4 per gallon in many cases.[16] Political resistance to raising the federal gas tax also further challenges to the cost competitiveness of EVs. Experts have recommended that the flat 18.4 cent per gallon tax, which has not increased in over 25 years and has lost over 35 percent of its purchasing power since 2003, be increased to fund road infrastructure investments needed to support the U.S. transportation system.[17] Without the additional price signals provided by adjusting fuel taxes, drivers may be less compelled to switch – or switch early on – to electric transportation modes. In sum, while total cost of ownership may be an important factor in some vehicle purchase decisions, upfront vehicle purchase price differentials may still discourage drivers from moving toward EVs.

Limited Model Diversity and Availability

Despite the growing number of EVs available in the market today, customers are still challenged by a lack of EV model diversity and availability. According to U.S. Department of Energy, there are currently 70 light-duty EV models available in the U.S. – comprised of 36 BEV models and 34 PHEV models. The table below shows the breakdown of these models by body type in comparison to the total number of model year 2019 vehicles available.[18]

Table 2 Light-Duty Vehicle Model Availability by Body Type

Body Type	(Sub)compact/ 2-seater	Mid-Large Sedan	Wagon and Van	SUV	Pickup Truck
EV models	15	35	5	15	0
Non-EV Models	394	303	58	352	126

Source: U.S. Department of Energy, fueleconomy.gov

While the number of EV models available in the California and U.S. is expected to materially increase throughout the early 2020s, model availability will constrain consumer choices and EV sales in the short-term. Shifting consumer preferences toward light trucks (e.g. SUVs, pickups, and vans) also creates headwinds for the EV market, which is only beginning to produce vehicles with these body types. According to the California New Car Dealers Association, nearly 57 percent of new light-duty vehicle sales in the state in the first half of 2019 were light trucks, compared to only 50 percent two years previously.[19] Automakers have recognized this trend and developed EVs that adapt to changing customer preferences; however, the larger batteries needed for these body types will drive additional costs that may make it more challenging for larger vehicles to achieve upfront cost parity with ICE vehicle counterparts in the near-term.

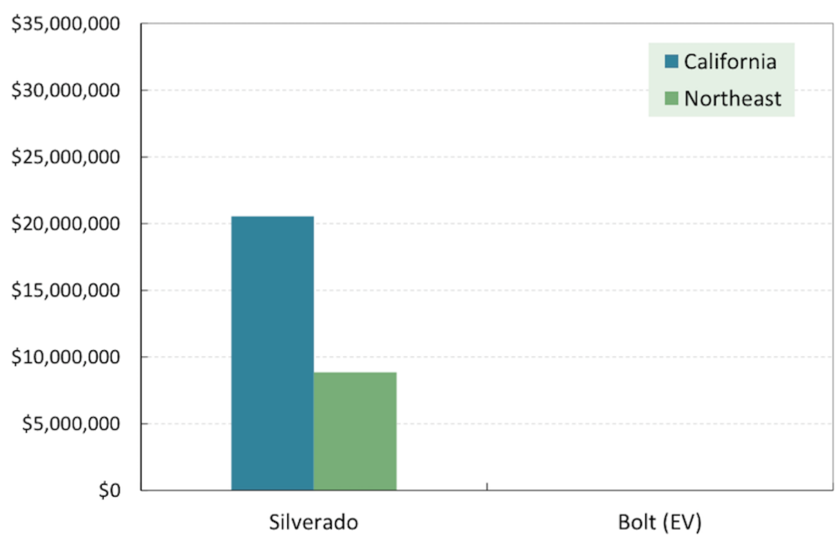
---

[16] https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_sca_dpg&f=m
[17] National Academies of Sciences, Engineering, and Medicine 2019. Renewing the National Commitment to the Interstate Highway System: A Foundation for the Future. Washington, DC: The National Academies Press. Available at: https://doi.org/10.17226/25334.
[18] https://www.fueleconomy.gov/feg/download.shtml
[19] https://www.cncda.org/wp-content/uploads/Cal-Covering-2Q-19.pdf; https://www.cncda.org/wp-content/uploads/California-Covering-2Q-2018.pdf

Lack of EV Education and Awareness

General consumer and dealership knowledge gaps continue to challenge EV sales growth. A UC Davis survey found that despite significant year-over-year growth of the EV market in California, only 5 percent of households owned or actively considered purchasing an EV in 2014 and that percentage largely remained the same in 2017.[20] Moreover, consumers' ability to identify one EV model declined over the same time period. UC Davis also finds no meaningful increase in the number of customers that have claimed to have seen a charging station outside of the home despite the doubling of public charging infrastructure in California between 2014 and 2017. While automakers and other stakeholders have ramped up investment in marketing as additional EV products come to market, relative investment remains low compared to automaker spending on ICE vehicle advertising. Data from InterQ Research revealed that on average, the six automakers with the greatest EV sales (excluding Tesla) in 2018 spent $38 million per top-selling ICE vehicle and approximately $3.7 million per EV on marketing in California and Northeast U.S. markets combined.[21] A striking example of this phenomenon is shown in the figure below comparing General Motors ad spend on the Chevy Silverado against the Chevy Bolt; Bolt ad spending was *de minimis* in both regions.

Figure 2 2018 General Motors Ad Spend: Chevy Silverado and Chevy Bolt



In some cases, auto dealerships may also not have the resources to effectively market and sell EVs. Although automakers may offer trainings to dealerships that sell EVs, frequent turnover among salespeople may make it challenging to retain and socialize knowledge. A recent dealer survey from Cox Automotive also suggests that dealers nationwide may not find EV sales to be economically attractive: 54 percent of dealers perceive lower profits and ROI from EV sales relative to ICE vehicles.[22] This survey result may be in part due to EVs requiring less dealer maintenance than ICE vehicles. Apart from the

[20] https://its.ucdavis.edu/blog-post/automakers-policymakers-on-path-to-electric-vehicles-consumers-are-not/
[21] https://www.nescaum.org/documents/2018-ev-marketing.pdf/
[22] https://d2n8sg27e5659d.cloudfront.net/wp-content/uploads/2019/08/2019-COX-AUTOMOTIVE-EVOLUTION-OF-MOBILITY-THE-PATH-TO-ELECTRIC-VEHICLE-ADOPTION-STUDY.pdf

vehicles themselves, dealerships may have very little information on electric utility rates and how EV fueling costs compare to gasoline powered vehicles – a critical selling point for economically-motivated vehicle purchasers.

The lack of EV awareness and education was evident in the light duty vehicle focus group conducted by the ICF team in September 2019. Several participants seemed unaware that EV owners typically charge their vehicles at home, and that a standard 110 volt outlet can be used to charge an EV. Some participants were also unaware of the range and performance of typically EVs. Overall, greater understanding of EVs' availability and capabilities are needed among consumers and dealers to accelerate EV adoption.

Lack of Accessible Charging Infrastructure

A robust network of charging infrastructure where drivers live, work, and play is foundational to the growth of the EV market. Despite the significant progress that California has achieved in deploying charging stations to support EV adoption, the San Bernardino County Zero Emission Vehicle Readiness and Implementation Plan states that lack of accessible refueling options continues to be a critical barrier for drivers looking to adopt EVs.[23] In partnership with the National Renewable Energy Laboratory (NREL), the California Energy Commission (CEC) developed a state-wide gap analysis to estimate charging infrastructure needs for achieving the 1.5 million zero-emission vehicle (ZEV) goal Governor Brown's Executive Order B-16-2012 by 2025.[13] Using the Electric Vehicle Infrastructure Projection (EVI-Pro) tool, CEC and NREL developed quantitative estimates of charging infrastructure needs broken out by county and charging technology.

EVI-Pro is a tool for projecting consumer demand for electric vehicle charging infrastructure.[24] EVI-Pro was been developed through a collaboration between the National Renewable Energy Laboratory (NREL) and the California Energy Commission, with additional support from the U.S. DOE. EVI-Pro uses detailed data on personal vehicle travel patterns, electric vehicle attributes, and charging station characteristics in bottom-up simulations to estimate the quantity and type of charging infrastructure necessary to support regional adoption of EVs. The tool depends on assumptions for the number of EVs to be added to an area, the mix of EVs (PHEV vs. BEV, by range), availability of home charging, and other factors. Results are reported in terms of the number of charging plugs for Workplace Level 2 Charging, Public Level 2 Charging, and Public DC Fast Charging.

In a scenario where California achieves the 1.5 million ZEV goal, EVI-Pro estimates that approximately 45,000 EVs will need to be on the road in San Bernardino County to proportionately contribute to the ZEV goal.[25] The table below illustrates NREL/CEC estimates for charging infrastructure needed to support this level of EV adoption by 2025.

[23] https://www.gosbcta.com/wp-content/uploads/2019/11/SBCOG-ZEV-Plan_Final-Online-Version-11619.pdf
[24] https://afdc.energy.gov/evi-pro-lite
[25] https://www.nrel.gov/docs/fy18osti/70893.pdf

Table 3 Estimated EV Charger Needs in San Bernardino County to Meet 2025 ZEV Goal

Charging Technology/Location	Current Charger Quantity	NREL/CEC Low Case (Chargers)	NREL/CEC High Case (Chargers)
Workplace Level 2	Unknown	1848	1997
Public Level 2	404	1444	2669
Public Direct Current Fast Chargers	54 Non-Tesla DCFC, 112 Tesla Superchargers	156	598

Source: NREL, CEC, U.S. DOE

Current levels of L2 and DCFC in the County are well below the estimates from the EVI-Pro analysis, demonstrating there is significant need for additional charging infrastructure deployment in the region in the market segments above. Given that California has a subsequent ZEV goal of 5 million EVs by 2030, these infrastructure estimates should be viewed as a “floor” rather than a “ceiling.”[26]

Deploying EV charging stations in multi-unit dwellings (MUDs) also remains a significant challenge for several reasons. First, deploying charging stations at MUDs is generally more expensive per-charger than single-family residential settings due to more complex site engineering needs and infrastructure upgrades required to support EV charging. While new 2020 CALGreen building codes require new MUDs (and other buildings) to be equipped to support EV charging at a minimum of 10 percent of parking spaces, many existing buildings were developed prior to the implementation of EV-ready building codes and require electrical capacity upgrades before EV charging stations can be deployed.[27] Additionally, residents at MUDs may face additional challenges to deploying infrastructure if they do not own their own parking space; deeded parking spaces that are owned by tenants may be costly to serve and switching parking spaces to serve EV drivers requires a legal transfer of property – adding an additional and potentially time-consuming step to the deployment process.[28] Finally, barriers to MUD charging are magnified at rental properties, where tenants may be reluctant to invest in EV charging infrastructure they may not use after they move from the property and property managers may not seek to deploy charging infrastructure in EV-only parking spaces without long-term assurance those assets will be used.

Despite deploying more charging stations than any other state, California also continues to struggle with streamlining permitting processes at the municipal level. To address permitting issues related to EV charging station installations, California passed Assembly Bill 1236 (AB 1236, 2015), which requires all cities and counties to develop expedited permitting processes for all EVSE “to achieve the timely and cost-effective installation of electric vehicle charging stations.”[29] To track compliance with the law, the Governor’s Office of Business and Economic Develop (GO-Biz) recently released a map scoring local jurisdictions on their permit streamlining efforts. GO-Biz finds that San Bernardino County as a whole is “in progress” with compliance, but is notably missing an online permitting checklist and timeline to fully

[26] https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html
[27] http://businessportal.ca.gov/wp-content/uploads/2019/07/GoBIZ-EVCharging-Guidebook.pdf
[28] https://www.veloz.org/wp-content/uploads/2017/08/MUD_Guidelines4web.pdf
[29] http://businessportal.ca.gov/wp-content/uploads/2019/07/GoBIZ-EVCharging-Guidebook.pdf

meet the requirements of the law. The map was incomplete at the time this memo was written, but of the cities that have already been evaluated by GO-Biz, Colton, Hesperia, and Big Bear Lake are "Not Streamlined." Jurisdictions that do not comply with AB 1236 are at risk of unnecessarily extending infrastructure deployment timelines, adding to installation costs, and ultimately slowing EV adoption in the state.

Fuel Cell Vehicles

FCVs represent an emerging technology solution to address LDV emissions, with over 7,700 light-duty FCVs on the roads in the U.S. today – the overwhelming majority located in California.[30] Although California has demonstrated a commitment to the growth of FCV adoption, FCVs still face a number of hurdles that challenge their penetration in the near-term.

High Upfront Vehicle Costs

FCVs are significantly more expensive than ICE vehicles on an upfront cost basis, and more expensive than comparable EVs as well. The Toyota Mirai, comparable to a Toyota Prius in size and appearance, has a MSRP of $58,500. The Hyundai Nexo, comparable to the Hyundai Kona, has a MSRP of $58,300. These vehicle prices typically include hydrogen fuel for the first three years or up to $13,000-$15,000 – whichever comes first. New FCVs were eligible for California Clean Vehicle Rebate incentives of $5,000 per vehicle until early December 2019; the rebate level has since dropped to $4,500 per vehicle.[31] While these vehicle incentives and fueling provisions are non-trivial, they do not completely address the FCV upfront price premium relative to ICE vehicles and EVs.

For hydrogen fueling that occurs beyond the automakers' fueling provisions, costs typically exceed comparable gasoline or electricity costs. According to the California Fuel Cell Partnership, hydrogen prices range from $12.85 to upwards of $16 per kilogram (kg).[32] At $14 per kg, the price per energy equivalent to gasoline translates to $5.60 per gallon. NREL estimates that fuel prices could drop to $8-$10 per kg within the 2020-2025 period, at which point FCVs would approach fuel cost parity with ICE vehicles, but hydrogen may still be more costly depending on future gasoline prices.

Limited Model Diversity and Availability

There are only three FCV models available for sale in California: the Honda Clarity Fuel Cell, Hyundai Nexo, and Toyota Mirai. The Honda Clarity Fuel Cell is only available via lease. While the Hyundai Nexo is an SUV, the overall scarcity of model options may deter potential drivers from exploring and purchasing FCVs.

Lack of FCV Education and Awareness

Similar to EVs, FCVs are also challenged by a lack of driver and dealer education. However, these education and awareness issues may be even more acute for FCVs: with only three available models and

---

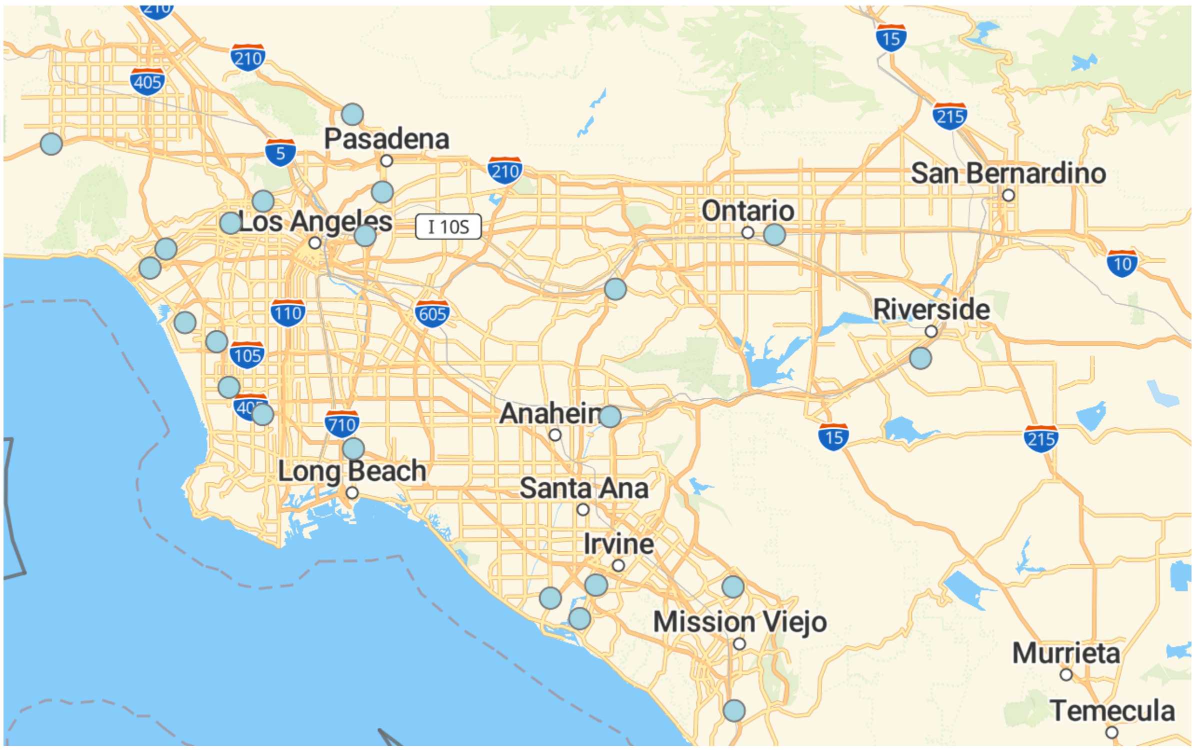
[30] https://cafcp.org/by_the_numbers
[31] https://cleanvehiclerebate.org/eng/faqs/what-should-i-know-about-december-3rd-program-changes
[32] https://cafcp.org/content/cost-refill

cumulative FCV sales amounting to approximately one percent of cumulative EV sales in California, FCVs may struggle to maintain visibility among customers today.

Lack of Accessible Fueling Infrastructure

Hydrogen fueling infrastructure cost is perhaps the most significant barrier to the development of the light-duty FCV market. All-in costs, including installation and overhead, are around $2.5 million per 180 kg/day station and up to $4 million per 360 kg/day station according to the CEC.[33] The majority of these station costs are funded by the CEC today. Additionally, the California Hydrogen Fuel Cell Partnership notes there are currently 42 public hydrogen fueling stations in the state.[34] Only one station is currently located within San Bernardino County in Ontario, with one additional station in planning stages in Chino (see below).[35] Given the limited availability of refueling infrastructure for FCVs in the near term, these vehicles will be challenged to achieve greater levels of adoption in San Bernardino County.

Figure 3 Hydrogen Fueling Stations in Southern California



Source: U.S. Department of Energy, Alternative Fuel Data Center

Ethanol Fuels

Gasoline in California is currently blended with 10 percent ethanol by volume (E10) and contributes to light-duty vehicle GHG emission reductions. E15, or gasoline blended with 15 percent ethanol by

[33] https://www.energy.ca.gov/2017publications/CEC-600-2017-011/CEC-600-2017-011.pdf
[34] https://cafcp.org/by_the_numbers
[35] https://cafcp.org/sites/default/files/h2_station_list.pdf

volume, could augment these emission reduction benefits. However, transitioning to E15 fuel requires overcoming several key challenges.

Ethanol can also be used in higher level blends, up to 85 percent (E85). While low-level ethanol blends can be used in gasoline-powered vehicles without alterations, E85 has different properties than gasoline. Consequently, only automobiles with compatible fuel systems and powertrain calibration can operate using the fuel. These vehicles are referred to as flexible fuel vehicles (FFVs). FFVs have an internal combustion engine and are capable of operating on gasoline, E85, or a mixture of the two. From the driver's perspective, the only difference between FFVs and conventional gasoline-powered vehicles is the reduced fuel economy when using E85 or other mid-level blends. Gasoline-powered vehicles can be converted to FFVs, although it requires extensive modifications to the original vehicle. San Bernardino County currently has approximately 74,000 registered FFVs, or about 4 percent of total registered vehicles.[36] However, many of these vehicles operate primarily or exclusively on gasoline.

Uncertain Regulatory Processes

For fuel sold as gasoline in California, the maximum ethanol blend currently allowed is 10 percent. The use of E15 in California would constitute the sale of a new transportation fuel, which is subject to a state-level multimedia evaluation pursuant to California Health and Safety Code section 43830.8.[37] This evaluation involves a peer-reviewed assessment of public health and environment impacts of E15 use, review by the California Environmental Policy Council, and potential implementation modifications to mitigate adverse impacts to public health or the environment. Should E15 be approved as a transportation fuel in California, vapor recovery devices and fueling hardware would still need to be approved by Underwriter Laboratories for use with E15.[38]

Compatibility Issues with Existing Vehicles and Gasoline Fueling Infrastructure

The U.S. Environmental Protection Agency (EPA) has approved the use of E15 for use in vehicles newer than model year 2001. However, for older vehicles, E15 may cause corrosion in vehicle fuel systems and affect the performance of emission control devices. While this vehicle compatibility issue will not be a significant barrier in the long-term, some automakers still do not approve the use of E15 in their new vehicles.[39] BMW, Daimler, Mazda, Nissan, Subaru, and Volvo have not approved E15 for all or some of their respective model year 2019 vehicles – potentially diluting the emission reduction impact E15 could have in California. Given these vehicle-related restrictions on E15, distributors of E15 are also required to adopt an EPA-approved Misfueling Mitigation Plan, which include placing informational labels on dispensers, participating in compliance surveys, and maintaining records of all E15 transfers via Product Transfer Documentation.[40]

Infrastructure upgrades present additional challenges. The California Air Resources Board (CARB) maintains that E15 is also not suitable for distribution in existing petroleum pipelines due to

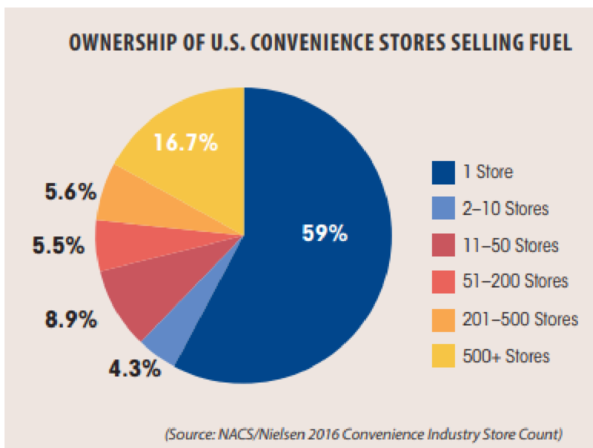
[36] Department of Motor Vehicles, https://www.dmv.ca.gov/portal/dmv/detail/pubs/media_center/statistics
[37] https://ww2.arb.ca.gov/sites/default/files/2018-10/CalEPA_Fuels_Guidance_Document_10-2-18.pdf
[38] Id.
[39] https://ethanolrfa.org/wp-content/uploads/2019/02/RFA2019Outlook.pdf
[40] https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=P100N3I5.pdf

compatibility issues with jet fuel.[41] Distributing E15 may then require additional infrastructure upgrades to support fuel sales. Retailers offering E15 will also need to retrofit existing dispensers with UL-listed conversion kits, purchase a UL-listed E25 dispenser, or purchase a UL-listed E85 dispenser.[42] Additionally, some underground storage tanks (USTs) used to store E10 may not be compatible with E15 and some USTs that are compatible with E15 may not be UL-listed.[43] Coupled with the fact that fuel retailers are not required to keep records on equipment specifications, it may be challenging for these retailers to determine whether they need to upgrade their USTs prior to selling E15.

Decentralized Status of Fuel Retailer Market

If E15 fuel is authorized for retail sale as an option among other gasoline-based fuels, the decentralized nature of the fuel retailer market may pose challenges for the broad adoption of E15. Although many gasoline retailers are branded with support of major oil companies, oil companies own a vanishingly small number of retail fueling stations nationwide. Four out of every five gallons of gasoline consumed by Americans are purchased at convenience stores, and as shown in the figure below, nearly 60 percent of these convenience stores are single-store operations.[44] 72 percent of stations are owned by retailers that own 50 or fewer stores.

Figure 4 Ownership of U.S. Convenience Stores Selling Fuel



Source: NACS

Given this market dynamic, decisions to incorporate E15 would likely take place at the gas station level and potentially slow the adoption of E15 relative to a scenario where retail station ownership was more concentrated. The CEC estimates that there are 400-799 gas stations in San Bernardino County, meaning that the widespread availability of E15 would likely be dependent on the individual decisions of hundreds of individual gas station owners if E15 sales were permitted.[45] For branded stations, there may

[41] https://ww2.arb.ca.gov/sites/default/files/2018-10/CalEPA_Fuels_Guidance_Document_10-2-18.pdf
[42] https://afdc.energy.gov/files/u/publication/e15_infrastructure.pdf
[43] https://ethanolrfa.org/wp-content/uploads/2019/06/retailadvisory.pdf
[44] https://www.convenience.org/Topics/Fuels/Documents/2016/2016-Retail-Fuels-Report
[45] https://ww2.energy.ca.gov/almanac/transportation_data/gasoline/piira_retail_survey.html

also be minimum E15 sales volume requirements stipulated by oil companies or refineries that present new contract risks for retailers.[46]

E85 Fueling Infrastructure

There are currently seven public E85 fueling stations in San Bernardino County, and most are co-located with a Chevron or 76 gasoline fueling station. Because FFVs can run on gasoline available at hundreds of other gas stations in the county, it is unlikely that FFV drivers would refuel at an E85 station unless it was located on or near their typical commute or if E85 were significantly cheaper than gasoline. If FFV adoption were to increase, it is likely that many more E85 stations would be needed to achieve the emissions reduction benefits associated with E85. However, because E85 and gasoline are substitutes in FFVs, drivers may still drive FFVs on gasoline if it is a more convenient or accessible fueling option.

Ethanol Feedstocks and Carbon Intensity

The vast majority of ethanol produced in the U.S. and consumed in California is made from corn. According to CARB, typical corn ethanol has a 27-48% lower carbon intensity (CI) compared to pure gasoline on a lifecycle basis.[47] Much lower GHG reductions are possible from ethanol produced from cellulosic material because the feedstocks are either waste, co-products of another industry (wood, crop residues), or are dedicated crops (such as switchgrass) with low water and fertilizer requirements compared to corn.[48] For example corn stover and corn kernel fiber projects can have a 58-69% lower CI relative to gasoline.[49] Supply of cellulosic ethanol is limited, however, because it is typically more expensive to produce than corn ethanol. There are also near-term concerns about evaporative emissions from E15 and its contribution to smog formation. Until recently, EPA banned the sale of E15 during summer months due to these emissions concerns; however, EPA announced in May 2019 that it lifted its restriction on the summertime use of E15.[50] The move has drawn a lawsuit from small fuel retailers as well as public opposition from the oil industry.[51]

Lack of Awareness and Education about Ethanol

Many, perhaps most, light duty vehicle owners and operators lack a basic understanding of ethanol and FFVs. Even in corporate and government fleets that comprise FFVs, drivers are sometimes unaware that the vehicles can be fueled with E85. In the focus group conducted by the ICF team in September 2019,

---

[46] https://afdc.energy.gov/files/u/publication/e15_infrastructure.pdf
[47] https://ww3.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all.xlsx Assumes the typical carbon intensity of corn ethanol is between 50-70 gCO2e/MJ. Note that the carbon intensity of pure corn ethanol is much lower than E15, which contains up to 15% ethanol.
[48] U.S. Department of Energy, Alternative Fuel Data Center. https://afdc.energy.gov/fuels/ethanol_fuel_basics.html
[49] https://ww3.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all.xlsx Assumes the typical carbon intensity of corn stover and corn kernel fiber projects are 30-40 gCO2e/MJ.
[50] https://www.epa.gov/newsreleases/epa-delivers-president-trumps-promise-allow-year-round-sale-e15-gasoline-and-improve-0
[51] https://www.reuters.com/article/us-usa-ethanol-lawsuit/small-fuel-retailers-sue-trump-epa-over-e15-gasoline-rule-filing-idUSKCN1UZ25M

most participants claimed that they did not have enough information about ethanol vehicles to comment on their pros and cons.

3. Medium- and Heavy-Duty Vehicles

Electric Vehicles

EVs are a promising zero-emission technology with relatively low operational costs. However, these vehicles face notable challenges in the MDV and HDV segments.

High Upfront Vehicle Costs

Similar to light-duty EVs, medium- and heavy-duty EVs have experienced significant cost declines as battery technology and manufacturing improves. However, battery costs continue to be the primary driver for vehicle cost differentials between EVs and ICE vehicles. Based on recent literature, ICF estimates the average upfront cost of a new electric transit bus is $820,000, while the average cost of a new, comparable diesel bus is around $435,000.[52] Electric medium-duty vans and trucks were estimated to cost approximately $130,000-$170,000 whereas the conventional diesel vehicle costs approximately $80,000 in 2015.[53] Estimates for heavy-duty trucks are more speculative given the current limited availability of electric models. Class 6-8 short-haul electric trucks are priced around $200,000-$300,000 relative to $145,000 for a comparable diesel truck; given that many electric trucks in the U.S. are imported from China, the electric truck prices include estimated tariffs levied on the import of these vehicles. Electric drayage trucks were estimated to cost $208,000 relative to $108,000 for conventional drayage trucks in 2020.[54] Thor and Tesla estimate their long-haul Class 8 semi-trucks will cost approximately $150,000-$250,000 depending on model's range, compared to $125,000 for a diesel equivalent.[55]

Given these higher upfront costs, the adoption of EVs in these segments has been heavily dependent on grants and incentives. Since 2009, CARB and CALSTART have administered the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). The HVIP Program has approved 3,400 vouchers worth $387 million toward the purchase of zero-emission vehicles, the majority of which have been EVs.[56] 234 of these vouchers worth over $26 million have supported the purchase of zero-emission vehicles in San Bernardino County. While the program has been a boon for the adoption of medium- and heavy-duty EVs, HVIP funding is limited relative to demand. A week after HVIP funding was replenished with $142 million in fiscal year 19-20 funding, the program was oversubscribed and placed on hold.[57] While this demand for HVIP funding demonstrates strong interest in EVs, it also highlights the reliance on near-

52 http://www.caletc.com/wp-content/uploads/2019/01/Literature-Review_Final_December_2018.pdf
53 *Id.*
54 ICF Resources, LLC, Economic Impacts of the Accelerated Deployment of Zero- and Near-Zero NOx Emissions Technologies in the Heavy-Duty Vehicle Sector Task 2: Implementation Scenarios Technical Memorandum, May, 1, 2019
55 *Id.*
56 https://www.californiahvip.org/tools-results/#program-numbers
57 https://content.govdelivery.com/accounts/CARB/bulletins/2699f43

term government incentives to support the market. Stop-start funding cycles can increase fleet owners' uncertainty about transitioning to EVs and ultimately hinder near-term EV adoption. South Coast Air Quality Management District's (SCAQMD) Voucher Incentive Program (VIP) also offers complementary incentives for small fleets up to $60,000 per truck.[58] While these incentives are significant, they may not be enough to encourage fleet owners to move toward EVs given their upfront price premium.

Limited Model Availability

The number of commercial EV model offerings continues to grow, but availability is still limited relative to ICE vehicles – particularly in the heavy-duty long-haul segment. The table below reveals eligible EV models under the HVIP program, including a small number of conversions. All Class 7-8 trucks eligible for incentives are delivery or other short-haul trucks.

Table 4 EV Models Eligible for HVIP Incentives

Transit Bus	School Bus	Class 3 Truck	Class 4-6 Truck	Class 7-8 Truck
29	16	6	32	14

While semi-truck manufacturers such as Tesla, Freightliner, and Navistar have all announced commitments to selling all-electric trucks, these trucks are not expected to begin production until the early to mid-2020s, limiting their effectiveness as a near-term solution for addressing emissions from HDVs.

Negative Views of EV Performance

Closely related to model availability challenges are real and perceived notions of inferior EV performance among fleet owners. Long-haul semi-trucks currently face clear challenges to electrification due to limited electric range relative to their diesel counterparts, which may disrupt the typical duty cycle of long-haul trucks. These challenges are reflected in the concerns raised by stakeholders in the September 2019 focus group conducted by the ICF team; participants noted that the combination of range and limited charging infrastructure would severely curb any interest in electric semi-trucks. Truck drivers in the focus group stated they drive between 100 and 500 miles a day. While the upgraded Tesla Semi is equipped to drive an estimated 500 miles on a single charge, the base Tesla Semi model and upcoming Freightliner eCascadia long-haul Class 8 trucks are expected to achieve 250-300 miles of range. Given the size of the batteries in these vehicles, the time required for on-route charging may not be feasible for some fleet owners.

Aside from range concerns, truck drivers in the focus group had several additional issues with EVs, including skepticism about the overall life of the battery, likelihood of battery overheating, lack of vehicle torque and power, high vehicle costs, and lack of charging infrastructure along major routes.

For some heavy truck operators, a switch from diesel to EV could also reduce payload carrying capacity. Because of the large battery needed to power a heavy electric truck, the empty (tare) weight of the

---

[58] http://www.aqmd.gov/docs/default-source/VIP/vip_brochure_english.pdf?sfvrsn=23

vehicle may be higher than a comparable diesel truck. Carriers that are transporting relatively dense, heavy cargo might need to reduce their payload in order to comply with federal and state weight limits. However, Assembly Bill 2061 of 2018 increases the state weight limit for near-zero and zero-emission vehicles by up to 2,000 pounds to compensate for the additional weight of batteries and other applicable powertrain components.[59]

Lack of Accessible Charging Infrastructure

Accessible charging infrastructure is critical to the operation of medium- and heavy-duty EVs, and lack of charging infrastructure is currently a barrier to all classes of EVs. Although the industry is converging on standards for conductive (i.e. plug-based) charging such as J3068 for alternating current (AC) charging and J3105 for overhead catenary charging, infrastructure cost and optimization may prove to be a challenge for fleet operators considering EVs.

Infrastructure cost can be broken out into three primary categories: charging station costs, maintenance costs, and "make-ready" costs, which include all costs related to upgrading electrical equipment upstream of the station to support EV charging. Although some medium- and heavy-duty EVs may utilize Level 2 charging equipment, which is relatively inexpensive and charges at a slower rate than DCFC stations, the battery capacities and duty cycles of these vehicles may require much faster charging in depot configurations. 50 kW charging stations may cost up to $50,000 per charger, while 150 kW and 350 kW stations may cost approximately $75,000 and $140,000 per charger, respectively.[60] However, these costs do not account for the electrical equipment upgrades needed to connect these charging stations to the grid. Estimated per-charger DCFC make-ready costs are shown in the table below.

Table 5 Per-Charger DCFC Make-Ready and Installation Costs

	50 kW				150 kW				350 kW			
	1 charger per site	2 chargers per site	3-5 charger per site	6-50 chargers per site	1 charger per site	2 chargers per site	3-5 chargers per site	6-20 chargers per site	1 charger per site	2 chargers per site	3-5 chargers per site	6-10 chargers per site
Labor	$19,200	$15,200	$11,200	$7,200	$20,160	$15,960	$11,760	$7,560	$27,840	$22,040	$16,240	$10,440
Materials	$26,000	$20,800	$15,600	$10,400	$27,300	$21,840	$16,380	$10,920	$37,700	$30,160	$22,620	$15,080
Permit	$200	$150	$100	$50	$210	$158	$105	$53	$290	$218	$145	$73
Taxes	$106	$85	$64	$42	$111	$89	$67	$45	$154	$123	$92	$62
Total	$45,506	$36,235	$26,964	$17,692	$47,781	$38,047	$28,312	$18,577	$65,984	$52,541	$39,097	$25,654

Source: International Council on Clean Transportation

While per-charger costs decline as the number of chargers per site increases, the magnitude of these deployment costs can be a significant barrier to adopting EVs.[61] These costs will only increase as EV

[59] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB2061
[60] Nicholas, Michael, *Estimating electric vehicle charging infrastructure costs across major U.S. metropolitan areas*, August, 2019, available at: https://theicct.org/sites/default/files/publications/ICCT_EV_Charging_Cost_20190813.pdf
[61] Southern California Edison's $342 million medium and heavy-duty infrastructure program, approved in May 2018 will help offset a portion of these costs at an estimated 840 sites to support the electrification of over 8,000

charging service providers explore the possibility of charging stations capable of delivering one megawatt of power or more.

Closely related to infrastructure constraints are fuel cost concerns. Electricity is generally a cheaper fuel than diesel on a per-mile basis. However, demand charges can significantly affect the economics of refueling EVs at DCFC stations, particularly for MD and HD vehicles. Demand charges recover costs based on a customer's highest instantaneous power demand (kW) during a given month or year as opposed to the energy (kWh) consumed at a site. Left unmanaged, DCFC stations can significant increase the peak electricity demand and customer electricity bills at a given site – particularly when multiple vehicles are fast charging simultaneously. SCE's recently approved commercial time-of-use (TOU) rate for EV customers shown below eliminates demand charges for customers during the first five years of enrollment and then gradually phases demand charges back into the rate design – allowing customers to become familiar with EV technologies and determine how to best manage their electricity demand.

Table 6 SCE TOU-EV-8 Electricity Rate for Commercial EV Customers

TOU-EV-8
Large Power with Monthly Max Demand between 21 - 500 kW

EV-Only		2019-2023	2024	2025	2026	2027	2028	2029+
TOU Period		All Energy Rate Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Full FRD Rate Year 11
Summer On - $/kWh	4-9pm weekdays	$0.41816	$0.41131	$0.40447	$0.39762	$0.39077	$0.38393	$0.25882
Summer Mid - $/kWh	4-9pm weekends	$0.27718	$0.27034	$0.26349	$0.25664	$0.24980	$0.24295	$0.20051
Summer Off - $/kWh	All except 4-9pm all days	$0.12550	$0.11866	$0.11181	$0.10496	$0.09812	$0.09127	$0.10135
Winter Mid - $/kWh	4-9pm all days	$0.27801	$0.27116	$0.26432	$0.25747	$0.25062	$0.24378	$0.20134
Winter Off - $/kWh	9pm-8am all days	$0.13206	$0.12522	$0.11837	$0.11152	$0.10467	$0.09783	$0.11078
Winter Super-Off- $/kWh	8am-4pm all days	$0.08133	$0.07448	$0.06764	$0.06079	$0.05394	$0.04710	$0.05837
Customer Charge ($/Month)		$106.75	$106.75	$106.75	$106.75	$106.75	$106.75	$106.75
FRD ($/kW)		$0.00	$1.99	$3.99	$5.98	$7.97	$9.97	$11.96
% of Final FRD		0	16.67%	33.33%	50.00%	66.67%	83.33%	100.00%
FRD % Increase By Year			16.67%	16.67%	16.67%	16.67%	16.67%	16.67%

Source: California Public Utilities Commission

This rate will likely help fleet owners manage their electricity costs as they transition to EVs. However, as demand charges get phased back in over time, operators of heavy-duty EVs will need to carefully manage electricity demand to ensure fuel cost savings relative to diesel fuel. Customers that can stagger and spread out EV charging over the course of the day will likely benefit the most from this rate design. However, customers that consume significant amounts of power in short periods of time will likely face more challenging refueling economics for their EVs.

Fuel Cell Vehicles

FCVs have the potential to provide clean transportation options to the long-haul heavy-duty segment. However, they face several critical challenges that may limit their adoption in the near-term.

---

medium and heavy-duty vehicles in its service territory. 40 percent of program budget must be invested in disadvantaged communities.

High Upfront Vehicle Costs

Reliable vehicle cost data is scarce due to the limited deployment of medium- and heavy-duty FCVs to date. However, it is clear that medium- and heavy-duty FCVs will command a high price premium relative to ICE vehicles in the near-term. In 2016, CARB estimated that fuel cell electric transit buses (FCEBs) cost approximately $1.235 million.[62] The NREL FCEB assessment from 2018 reveals that recent bus orders cost $1.27 million, down from $2.5 million in 2010.[63] An order of 40 buses could push costs closer to $1 million per FCEB.[64] Truck cost data is difficult to obtain. Nikola anticipates offering an all-in long-haul semi-truck, fueling, and maintenance cost package for around $900,000 over the million-mile life of the vehicle.[65] ICCT predicts that the total cost of ownership for heavy-duty FCVs may be 5-30% less than diesel vehicles in 2030, but these assumptions are dependent on hydrogen fuel and infrastructure costs declining over time and still suggest that FCVs will still cost more than diesel vehicles on an upfront basis.[66] However, new truck ownership and leasing models may make FCVs competitive on a cost per-mile basis with diesel trucks.[67]

Limited Model Diversity and Availability

FCV model availability is very limited in medium- and heavy-duty segments. Currently, only four FCV models are eligible for HVIP incentives – two of which are transit buses manufactured by New Flyer and two of which are transit buses manufactured by ElDorado National. According to the California Fuel Cell Partnership, 31 hydrogen transit buses are currently in operation in California and 21 are under development.[68]

Beyond transit buses, medium- and heavy-duty FCV deployments have primarily been limited to demonstration projects in port and parcel delivery applications. Toyota, in partnership with Kenworth, is testing fuel cell powertrains for Class 8 drayage trucks in the Los Angeles region: ten Kenworth T680 models outfitted with Toyota fuel cell technology will transport cargo from Ports of Los Angeles and Long Beach throughout the region and are expected to drive more than 300 miles per fill.[69] Nikola Motors is currently in the demonstration phase of producing two fuel cell tractor models that are expected to reach mass production around 2025 with ranges upwards of 500 miles per fill.[70] While these pilots are essential for assessing the performance of FCVs in real-world settings, their timelines suggest that FCVs will not be a near-term solution to addressing HDV emissions.

---

62 http://www.caletc.com/wp-content/uploads/2019/01/Literature-Review_Final_December_2018.pdf
63 https://www.nrel.gov/docs/fy19osti/72208.pdf
64 *Id.*
65 https://www.trucks.com/2019/04/17/nikola-unveils-trucks-launches-1-5-billion-investment-drive/
66 https://www.theicct.org/sites/default/files/publications/Zero-emission-freight-trucks_ICCT-white-paper_26092017_vF.pdf
67 https://www.truckinginfo.com/329836/nikola-plans-a-different-truck-ownership-model-for-its-hydrogen-and-electric-tru
68 https://cafcp.org/by_the_numbers
69 https://www.truckinginfo.com/330270/toyota-and-kenworth-unveil-jointly-developed-hydrogen-fuel-cell-truck
70 Couch et al., 2018 Feasibility Assessment for Drayage Trucks, prepared for The Port of Los Angeles and Port of Long Beach, April 2019, available at: http://www.cleanairactionplan.org/documents/final-drayage-truck-feasibility-assessment.pdf/

Lack of FCV Education and Awareness

Education and awareness issues surrounding FCVs are significant given the maturity of the technology and limited number of vehicles available to date. Their estimated ranges and fueling dynamics closely mirror those of diesel vehicles, providing FCVs with an advantage over EVs in this regard. However, the new powertrain and fuel associated with FCVs may cause concern for some fleet owners skeptical of new technology.

Lack of Accessible Fueling Infrastructure

As with LDVs, fueling infrastructure cost is perhaps the most significant barrier to the development of the medium- and heavy-duty FCV market. The larger fuel tanks in medium- and heavy-duty FCVs require higher capacity, more expensive fueling stations than LDVs: hydrogen stations for transit buses are reported to cost $5 million per station.[71] CEC awarded an $8 million grant to Shell for the development of one high-capacity hydrogen station at the Port of Long Beach.[72] Hydrogen stations are currently scarce in California (45 public fueling stations) and are virtually nonexistent beyond California – potentially limiting the opportunity for interstate FCV trucking operations in the near-term. As the U.S. Department of Energy notes, it is difficult to develop a comprehensive infrastructure network for distribution of hydrogen to hundreds or thousands of fueling stations.[73] Producing hydrogen on site may reduce distribution costs, but it raises production costs if on-site production facilities are not already available. Hydrogen costs do not provide any meaningful cost savings at current diesel prices.[74] In short, FCVs will continue to be challenged by high infrastructure costs and limited distribution networks in the near term.

Natural Gas Vehicles

NGVs provide a viable technological alternative to diesel vehicles while reducing emissions. However, NGVs share some similar challenges as medium- and heavy-duty EVs and FCVs as well as some unique regulatory risks.

High Upfront Vehicle Costs

Although upfront costs for medium- and heavy-duty NGVs are not as pronounced as other alternative fuel vehicles, they may still present a barrier to adoption. Medium-duty NGVs have an incremental price between $25,000-$50,000 above comparable petroleum fueled vehicles while heavy-duty NGVs typically have an incremental price of $40,000-$60,000 over conventional diesel vehicles. This price increment is driven mainly by the cost of the fuel tanks for compressed or liquified natural gas.

Until October 2019, HVIP provided $40,000-$50,000 in incentives for 31 types of low-NOx vehicles and engines, including NGVs. However, new program modifications came into effect in October that eliminates HVIP funding for low-NOx vehicles and engines with the exception of the 11.9L low-NOx

---

[71] https://h2stationmaps.com/costs-and-financing
[72] https://www.energy.ca.gov/business_meetings/2018_packets/2018-11-07/Item_18_ARV-18-002.pdf
[73] https://afdc.energy.gov/fuels/hydrogen_production.html
[74] https://h2stationmaps.com/costs-and-financing

natural gas engine. Currently, only 14 NGVs and engines meet this new specification.[75] In addition, HVIP now requires all NGVs purchased with program funding to procure all fuel from in-state produced renewable natural gas (RNG), which may pose an additional barrier.[76]

Negative Views on NGV Performance

Despite the technological maturity of NGVs relative to other alternative fuels, NGVs still suffer from real or perceived concerns about vehicle performance. Truck drivers that participated in the heavy-duty vehicle focus group in September 2019 noted issues with the poor reliability of natural gas engines. Additionally, they noted that there may be a lack of qualified mechanics to service NGVs when they experience issues. Another describes potential safety concerns related to the flammability of natural gas in a potential accident scenario. Additionally, some expressed concern that the weight of NGVs brings down their performance relative to diesel vehicles.

Lack of Accessible Refueling Infrastructure

Natural gas fueling infrastructure options may be limited for certain fleets looking to transition to NGVs. For larger fleets that can take advantage of depot refueling opportunities, infrastructure costs may be substantial. Large, off-site natural gas fueling stations can cost up to $1.8 million in certain cases. The table below illustrates natural gas fueling infrastructure costs.[77]

Table 7 Natural Gas Fueling Infrastructure Costs

Size	Type	Examples of Vehicles Supported	Total Cost
Small Station (85-170 DGE per day)	Fast Fill	15-25 pickups/delivery vans	$400,000-$600,000
	Time Fill	5-10 refuse vehicles	$250,000-$500,000
Medium Station (425-680 DGE per day)	Fast Fill	50-80 medium-duty trucks	$700,000-$900,000
	Time Fill	25-40 refuse trucks	$550,000-$800,000
Large Station (1,275-1,700 DGE per day)	Fast Fill, Retail	More than 100 MDVs and HDVs	$1.2-$1.8 million

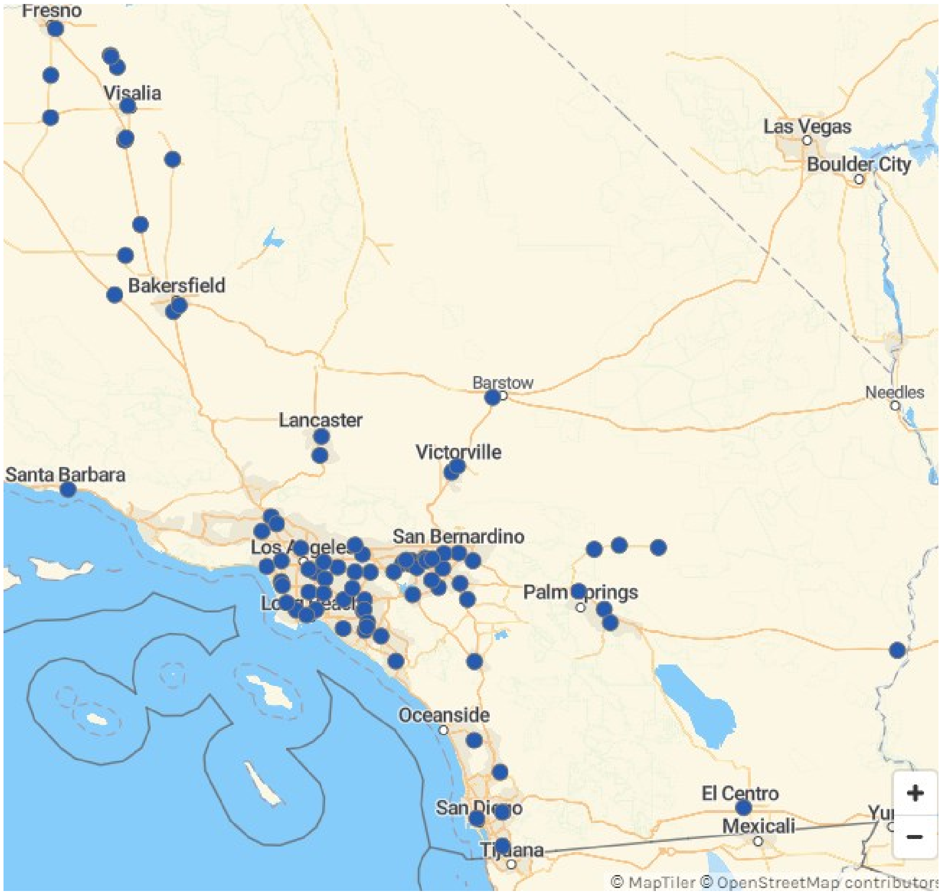
Unlike EVs, NGVs cannot currently take advantage of utility programs that support the deployment of fueling infrastructure. Natural gas fueling stations are, however, eligible for incentives under the Carl Moyer Program administered by the South Coast Air Quality Management District. Southern California Gas Company (SoCalGas) offers natural gas at discounted rates to customers fueling natural gas vehicles.[78]

For long-haul trucking operations, the current number of fast fill stations available today may deter some fleet owners from purchasing NGVs. While the greater Los Angeles area is relatively well-covered

[75] https://mailchi.mp/ee5457ceaf51/new-evse-voucher-requirements-for-hvip-770537?e=%5bUNIQID%5d
[76] https://www.californiahvip.org/low-nox-incentives/#low-nox-natural-gas-engines
[77] https://afdc.energy.gov/files/u/publication/cng_infrastructure_costs.pdf
[78] https://afdc.energy.gov/fuels/laws/NG?state=CA

by fueling stations today, other parts of the state and neighboring states have infrastructure gaps – shown in the figure below – that may preclude long-haul natural gas trucking operations in certain cases.

Figure 5 Heavy-Duty Fast Fill NGV Fueling Infrastructure Locations



Source: U.S. DOE

Regulatory Risks

Natural gas has traditionally been encouraged at the state and local level as an alternative to diesel fuel. However, pending and existing regulations promulgated by CARB may increase risks associated with transitioning to NGVs in certain circumstances and reduce the penetration of NGVs in the state.

The first example of regulatory risk is CARB's Innovative Clean Transit rule. Finalized in December 2018, the regulation establishes a requirement for transit agencies in the state to transition to completely zero-emission bus fleets by 2040.[79] To meet this goal, all new transit bus sales starting in 2029 must be zero-emission. Because CARB's definition of "zero-emission" is limited to all-electric and fuel cell buses in the regulation, California natural gas bus sales are anticipated to decline rapidly and end within the next decade. This regulation suggests that CARB is willing and able to exercise its authority to require

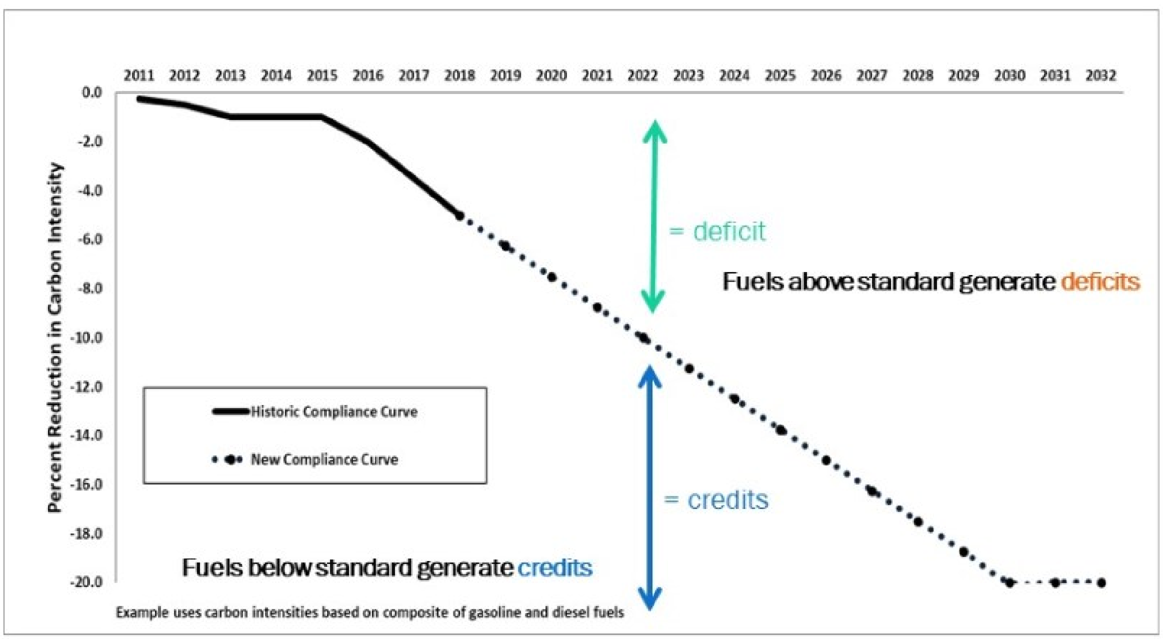
[79] https://ww3.arb.ca.gov/regact/2018/ict2018/ictfro.pdf

lower-emission alternatives to fossil fuels as those alternatives become more technologically and economically feasible.

CARB is moving ahead with the Advanced Clean Trucks Regulation, a rule that would require Class 2B-8 vehicle and chassis manufacturers to sell an increasing percentage of zero-emission trucks between 2024 and 2030. Specifically, the proposed regulation would require 50 percent of Class 4-8 truck sales to be zero-emission and 15 percent of all other medium- and heavy-duty truck sales (including Class 7-8 tractors) to be zero-emission by 2030.[80] The regulation would also require additional reporting to CARB from retailers, manufacturers, brokers, and other parties on vehicle shipments. While the proposed regulation does not prohibit the sale or use of NGVs, the regulation sends a strong market signal that the state is interested in advancing zero-emission vehicles across all vehicle classes. As a result of the proposed Advanced Clean Trucks Regulation, conservative fleet owners may also begin hedging against more aggressive future ZEV regulations by purchasing and become familiar with zero-emission technologies now.

Finally, the Low Carbon Fuel Standard (LCFS) may also create some additional challenges for the use of fossil natural gas as a transportation fuel. The LCFS is a market-based program designed to encourage cost-effective reductions in the carbon intensity (CI) of transportation fuels in California with a goal of achieving a 20 percent overall CI reduction in 2030 relative to 2010 levels. As shown below, regulated entities that produce fuels with CIs above the target CI in a particular year (e.g. gasoline and diesel) generate deficits while entities that produce fuels with CIs below the target CI (e.g. hydrogen and electricity) generate credits that can be sold on the LCFS market to parties with credit deficits.

Figure 6 Illustrative Graphic of LCFS Declining CI Curve



Source: CARB

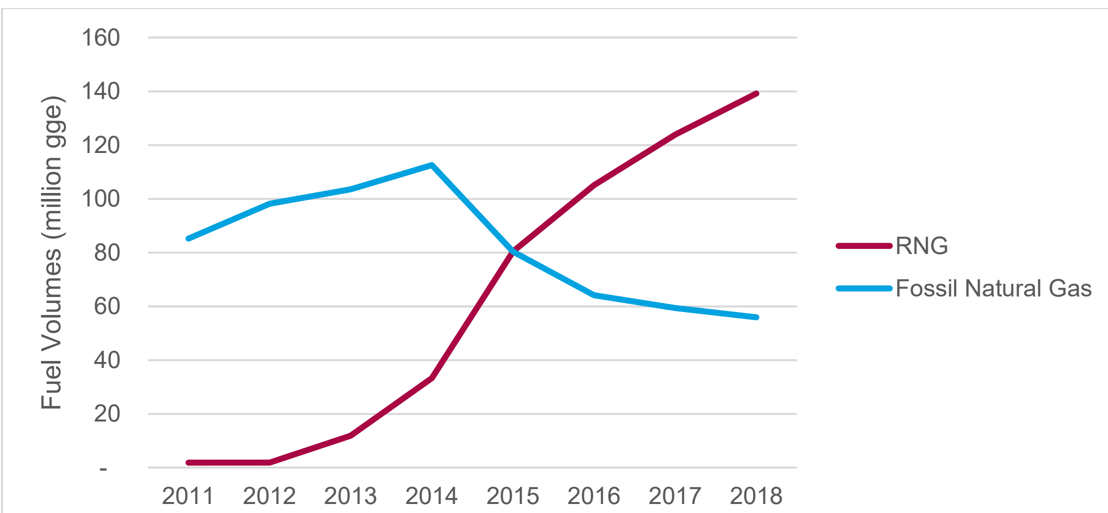
80 https://ww2.arb.ca.gov/sites/default/files/2019-08/190821draftregmanu_0.pdf

Fossil natural gas has generally been below the declining annual CI target in the early years of the LCFS and therefore has been eligible to generate credits that can then be sold for monetary value. However, as the program becomes more stringent and the annual CI target continues to decrease, some natural gas producers will transition from credit-generating parties to deficit generating parties. This change may reduce natural gas suppliers' interest in providing fossil natural gas as a transportation fuel, raise the cost of fossil natural gas as a transportation fuel, and ultimately reduce fleet interest in purchasing vehicles that use this fuel. Additionally, as it becomes more difficult for the transportation fuel mix to achieve the increasingly-stringent annual CI target, LCFS credit prices will continue to rise and raise the cost of producing carbon-intensive fuels – putting additional pressure on fossil natural gas.

Renewable Natural Gas Supply Risk

One solution to overcome the risks and limitations associated with the use of fossil natural gas is renewable natural gas (RNG), which can be used as a drop-in substitute in NGVs. RNG use is now required for NGVs purchased with HVIP incentives and generally has a significantly lower CI than fossil natural gas, meaning that RNG suppliers will likely continue to generate credits under the LCFS through 2030. The graph below illustrates how RNG has largely displaced fossil natural gas as fuel for NGVs in the LCFS program: approximately 70 percent of the natural gas used for transportation in California in 2018 was RNG.[81]

Figure 7 RNG and Fossil Natural Gas LCFS Annual Fuel Volumes



Source: CARB

While RNG has several advantages over fossil natural gas, concerns over limited supply and cost may create additional risk for transitioning to NGVs. First, California is not the only jurisdiction to implement a low carbon fuel standard. Oregon and British Columbia also have similar programs that encourage the production and distribution of RNG with increasingly strict CI targets. Additionally, the Puget Sound

[81] https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

region[82], Colorado[83], and Canada[84] are considering the implementation of LCFS in their respective jurisdictions, with Canada's Clean Fuel Standard coming into force as early as 2022. The growth of LCFS policies has the potential to increase demand for RNG and increase the value of low carbon intensity RNG – making more RNG projects economical. There is a small risk that the RNG market becomes increasingly supply-constrained, limiting the potential for California to secure RNG needed to meet transportation demand, but with the combined Federal RFS and LCFS incentives, transportation within the US will be a priority end destination for RNG over other uses. According to UC Davis, Canada's Clean Fuel Standard alone could nearly double the volume of fuels covered under a LCFS-style policy.[85] Additionally, the versatility of RNG as a source of building heat and electricity generation may create additional headwinds for use of RNG as a transportation fuel. If new programs or regulations in these sectors require or otherwise encourage the use of RNG, it could exacerbate supply constraints for RNG as a transportation fuel. California passed SB 1440 which requires the California Public Utilities Commission to consider the adoption of biomethane procure targets for utilities, which is a precursor to a renewable gas standard.[86] Finally, the use of RNG does not make NGVs "zero-emission vehicles" as defined by the Innovative Clean Transit regulation or the proposed Advanced Clean Truck regulation.

Biodiesel and Renewable Diesel Fuels

Biodiesel (B20) and renewable diesel (RD100) fuels are drop-in fuels that can be used in medium- and heavy-duty diesel trucks today. Despite the relative ease of incorporating these alternatives to diesel into the transportation fuel mix, they present their own challenges and risks.

Compatibility Issues with Existing Vehicles and Fueling Infrastructure

Although B20 is used interchangeably with diesel, there are additional precautions B20 fuel suppliers may consider before safely selling biodiesel. The Department of Energy provides a checklist for installing equipment to support B20 fueling, which includes the cleaning of storage tanks, labeling of B20 dispensers, verifying the use of UL-listed infrastructure, monitoring storage tanks for signs of corrosion from microbial growth, and notifying local fire departments about the use of B20 fuel.[87] Additionally, while cold weather is not commonplace in Southern California, concerns about the gelling of B20 at lower temperatures may also pose an additional barrier to the use of the fuel among some fleet owners.

Potentially Higher Emissions Profile than Alternatives

While RD100 has demonstrable GHG and NOx emission reduction benefits relative to diesel, B20 has shown minimal NOx abatement potential relative to diesel. In some cases, B20 blends have been shown

[82] https://pscleanair.gov/528/Clean-Fuel-Standard
[83] https://www.argusmedia.com/en/news/1965542-qa-colorado-lays-groundwork-for-lcfs
[84] https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html
[85] https://steps.ucdavis.edu/wp-content/uploads/2017/05/Witcover-BiofuelTracker-2017-2018-.pdf
[86] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1440
[87] https://afdc.energy.gov/files/u/publication/biodiesel_handling_use_guide.pdf

to produce more NOx than conventional diesel.[88] The has been a major barrier to use of biodiesel, particularly in Southern California. In January 2019, CARB updated the LCFS regulation to ensure that B20 fuel suppliers that participate in the program produce biodiesel in a manner that does not increase NOx emissions relative to conventional diesel and identify additives that would achieve this result.[89] Given the relatively minor NOx emissions reduction benefits of B20, widespread use of B20 may not advance the region's air quality goals to the same degree as RD100 or other alternative fuels.

Lack of Accessible Fueling Infrastructure

Access to B20 and RD100 is limited in San Bernardino County. The figure below illustrates where B20 stations are located in Southern California.

Figure 8 B20 Fueling Station Locations in Southern California

Source: DOE

Currently, there is only one public B20 fueling station in San Bernardino County in Ontario and one nearby station in Riverside County – reflecting the concerns about the NOx impacts of using biodiesel. Options for RD100 are even more limited. Neste, one of the largest RD100 producers globally, only has four stations available in Central and Northern California.[90] Fleet owners can also purchase RD100 direct from suppliers. However, if renewable diesel prices are comparable to diesel prices when accounting for LCFS credits and Renewable Fuel Standard renewable identification numbers (RINs), there is little

[88] https://ww3.arb.ca.gov/fuels/diesel/altdiesel/20140630carb_b20_%20additive_study.pdf?_ga=2.262185932.1549680135.1574709844-545298116.1556149337
[89] https://ww3.arb.ca.gov/regact/2018/lcfs18/frolcfs.pdf?_ga=2.35187297.1549680135.1574709844-545298116.1556149337
[90] https://www.neste.us/neste-my/find-fuel

incentive for fleets to procure RD100 if it is more convenient to fuel vehicles at conventional diesel stations.

Regulatory Risks

Like natural gas fuel, biodiesel and renewable diesel fuels face regulatory risk from existing and future clean vehicle regulations in California. The proposed Advanced Clean Truck regulation will require the sale and use of medium- and heavy-duty vehicles that do not run on biofuels, potentially curbing long-term fleet owner interest in pursuing these fuels from a regulatory risk viewpoint. B20 and RD100 are also federally incentivized by the Renewable Fuel Standard (RFS), a policy designed to encourage the increasing use of renewable fuels to displace petroleum-based transportation fuel demand. Qualified renewable fuel providers can generate RINs that can be sold on RIN markets in a manner similar to LCFS credits. However, the program's annual renewable fuel volume targets are only established through 2022.[91] While the RFS is unlikely to be terminated, there remains uncertainty surrounding how EPA – the RFS administrator – will extend the program and provide additional revenue opportunities for suppliers of renewable fuels.

Fuel Supply Risks

Biodiesel and renewable diesel fuels have played an important and growing role in achieving compliance with California's LCFS. However, both fuels face supply risks that may impact their viability in the long-term. Both fuels generally rely on the same feedstocks: animal fats, plant oils, and greases.[92] While increasingly higher LCFS credit prices will continue to make more biofuels production economically feasible, there is a risk that demand for these fuels may outstrip supply. This outcome may occur in part because of the inelasticity of certain feedstock supplies, meaning that their production will not necessarily increase in response to higher prices for that feedstock. In addition, the Innovative Clean Transit regulation requires large transit agencies, starting in 2020, to purchase only renewable diesel when renewing fuel purchase contracts which will increase the demand for these low carbon fuels. Combined with the possibility of additional LCFS programs launching in other jurisdictions, this demand-side pressure may strain economical biofuel production and limit the volumes of biofuels used for California LCFS compliance. Additionally, as other LCFS programs become established, biofuel producers strategically located near other covered jurisdictions may theoretically experience lower fuel transport costs to serve other LCFS markets – diverting biofuels that would have otherwise been imported by California.

4. Regulatory Authority

In addition to challenges specific to light-duty, medium-duty, or heavy-duty vehicles, other implementation challenges relate to the absence of regulatory authority at the local and regional level.

---

[91] https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard
[92] These feedstocks are also critical inputs in the production of other end-uses, and demand for these other products may affect the quantity of feedstock available for biofuel production.

Local Authority

Local governments and regional agencies do not have authority to regulate the sale or new or used vehicles. Thus, a municipality or agency such as SCAG, SBCTA, or AQMD could not require that vehicles must meet certain emissions standards, or that a certain fraction of vehicles comply with technology specifications.

Local and regional authority to influence vehicle sales is primarily limited to incentives. Local governments and regional agencies can offer incentive funding to help offset the cost of clean vehicles. For example, the City of Riverside offers up to $500 for the purchase or lease of a new EV. Most of the low and zero emission vehicle incentive programs in the region are provided by AQMD, many of which involve state funding. AQMD also offers an Old-Vehicle Scrapping Program, which provides cash payments to owners of old but functioning vehicles in return for agreeing to scrap the vehicle.

To generate funding for transportation improvements, counties can implement a local-option sales tax, with revenues dedicated to transportation projects. Twenty-five counties in the state have these programs, which requires super majority (two-thirds) voter-approval. In San Bernardino County, Measure I authorized a half-cent sales tax for transportation improvements; the measure was first approved in 1989 and an extension to 2040 was approved in 2004. Revenue from these programs must be spent in accordance with an expenditure plan. In San Bernardino County, the Measure I expenditure plan identifies highway projects, local street projects, and transit improvements (rail and bus) to receive funding.

State Authority

California has unique authority to regulate vehicle sales for emission reduction. In general, federal preemption prohibits states and local jurisdictions from enacting emission standards and other emission-related requirements for new vehicles and engines. However, the Clean Air Act (CAA) allows California to seek a waiver of the federal preemption, and in the past, this waiver was routinely granted, allowing California to set its own vehicle emission standards. In September 2019, the U.S. Environmental Protection Agency announced it is withdrawing California’s waiver under the CAA to set its own vehicle emission standards. That action is currently being challenged in court.

Under CAA waivers, California has in the past set tailpipe emission standards that were more stringent than federal standards, for both light-duty and heavy-vehicles. The CAA waiver was also used to establish California’s zero emission vehicle (ZEV) mandate, administered by CARB. Dating back to 1990, the program requires the largest vehicle manufacturers to deliver for sale a sufficient number of ZEV credit-producing vehicles – battery electric, plug-in hybrid electric, and fuel cell electric vehicles – such that each manufacturer attains specific ZEV credit and minimum ZEV sales percentages. The requisite percentages ramp up gradually through model year 2025.

5. Conclusion

The use of alternative vehicles and fuels remains a critical strategy for reducing on-road transportation sector emissions in San Bernardino County. California has made considerable progress in the development of policies and markets that have encouraged the adoption of cleaner vehicles and fuels. However, key economic, technical, and policy barriers remain. Vehicle and infrastructure costs pose challenges for most new technologies. General lack of awareness and perceptions of vehicle performance constitute significant barriers to widespread adoption of alternative vehicles. Finally, regulatory risks can increase costs and uncertainty for biofuel and fossil fuel producers. Identifying these challenges creates opportunity to develop solutions to advance clean vehicles and fuels in San Bernardino County.